International Journal of

Agricultural Research

ISSN 1816-4897

Academic
Journals Inc.

www.academicjournals.com

International Journal of Agricultural Research 2 (1): 11-21, 2007
ISSN 1816-4897

A Comparative Study of Pine Bark Substrate Alternatives in Tobacco (*Nicotina tabacum*) Float Seedling Production Systems

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Abstract: The present study was designed as Randomized Complete Block with three replicates, which were subjected to six treatments. Tobacco seedlings were grown in trays on float bed with treatments varying in growth media combinations as follows: T_1- 50% pine bark and 50% sand (control, farmer's present practice), T_2- 100% maize cobs, T_3- 100% groundnut shells, T_4- 50% maize cobs and 50% sand, T_5- 50% groundnut shell and 50% sand, T_6- 50% groundnut shells and 50% maize. The lowest seed germination was observed in T_2; T_3 and T_6 float trays, which, notably, did not include the sand matrix in the growth media cocktail. T_2 float trays had the highest tobacco seedling mortality where a modest 58.2% germination rate was attained before rapidly dwindling to 27.3% seedling survival rate at pulling stage. The growth media without the sand component in float bed system had the lowest seedling survival percentage of a paltry 27.3%. Control float trays supported the highest tobacco seedling survival rates of 80% at transplantable stage. All growth media with sand in their combinations had relatively high germination and seedling survival rates of 68.7-80.0% (T_1, T_4 and T_5). However, T_1 and T_4 quartz based seedling growth media produced comparatively higher spiral rooting rates of 1.0-2.2 and 0.8-2.3%, respectively. Growth media without sand component in T_3 and T_2 float trays generated the least spiral rooting rates of 0 and 0.7% at pulling stage, respectively. T_2 and T_4 growth media, which recorded relatively lower seedling survival counts of 27.3 and 54.2% had the heaviest shoot and root weights of 0.9 and 0.24 g; 0.89 g and 0.25 g per seedling, respectively. Growth media combinations in T_1 and T_3 coupled with T_5 float trays, which, notably, had the highest seedling survival rates of 80.0, 68.7 and 69.5% propagated the tallest stem lengths of 159.5, 137.9 and 155.6 mm, respectively at pulling stage. In our search for alternative media combinations to the traditional pine bark/sand mix, study results suggest that the five alternative media combinations did not expose better seedling growth media qualities in almost all the essential biometric characteristics of tobacco seedlings.

Key words: Organic growth media combination, float trays, tobacco seedlings

Introduction

The decomposition dynamics of organic substrate depends largely on the quality of the input such as the N concentration (Taylor *et al*., 1989), lignin: N ratio (Melillo *et al*., 1982) and its interaction

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with the substrate matrix. Plant litter can vary widely in its chemical constituents, presenting a possibility of an equally varied decomposer microbial community composition and function (Hyvonen and Agren, 2001; Myers *et al*., 2001).

In a study on the role of litter quality on decomposition and nutrient cycling Paustian *et al*. (1997) reported a significant influence of the potential rate of decomposition and accessibility to substrate for decomposers on the rate of organic matter decomposition. The composition of litter is the most commonly used determinant of organic substrate decomposition rate, but the physical properties of the substrate such as form, shape and size also influence the rate of decomposition. Berg and Staaf (1980) reported retarded microbial attack on substrate cellulose due to its lignin incrustation and impregnation with secondary substances at micro scale.

There is, however, conflicting literature as to which substrate quality parameter is best in describing the rate of decomposition of a particular substrate. According to Taylor *et al*. (1989), the C: N ratio is a better predictor of decay rate for substrates low in lignin when comparing substrates with a wide range of lignin contents. For substrates high in lignin, the decomposition rate would be more strongly influenced by lignin and this influence would begin earlier in the decomposition process. Hence, initial lignin content or lignin: N ratio would be a better predictor of the decomposition rate. In a study on the decomposition of *Eucalyptus* litter Skene *et al*. (1997) reported that the limiting factor to high quality substrate microbial decomposition is the physical protection by inorganic substrates, whereas for low quality substrates, chemical protection is the limiting factor.

Methods of organic matter treatment that would optimize seedling establishment are yet to be developed (Hallsby, 1995). However, Balisky *et al*. (1995) proposed that root morphologies and planting strategies would have to be site-specifically modified to promote the development into the organic/mineral soil interface. These authors suggested that planting into micro sites consisting of rotten wood or duff might be advantageous to seedling establishment while planting into mineral soil could be detrimental.

Composting is a time-honoured practice of encouraging partial rotting and accelerating the rate of humification of plant and animal residues by microorganisms in well aerated, moist heaps. To hasten decay, small quantities of fertilizer may be added along with a little soil to assure the presence of decay organisms (Salonius, 1972). Properly prepared composts, if supplemented by small quantities of commercial fertilizer and lime when needed, can be effective in supplying nutrients for plant growth and development (Johnson, 1998).

Blending different seedling growth media components generates physical and chemical characteristics that are intermediate between properties of the components (Blom, 1993). In the formulation of growth medium, it is critical to consider an appropriate balance between water holding capacity and aeration. Once the desired characteristics have been determined and the media components selected, a medium can be formulated to meet those characteristics. The two critical physical attributes of container media are aeration and water holding porosity, which constitute total porosity. For favourable physical characteristics to be present in the container media, total porosity should comprise over 50% of the media volume (Bilderback *et al*., 1999).

Presently, formulation of media components to achieve the desired properties is done by trial and error; although computer assisted models are being worked out to predict desired characteristics (Fonteno *et al*., 2001). Bilderback *et al*. (1999) reported increased moisture retention and available water content coupled with reduced air space and total porosity when pine bark is blended with sand to produce a growth media. In the sand media blending, there is possibility of air porosity reduction in which case careful irrigation management should be practiced in order to avoid water logging and seedling root anoxia. Sand blending in media formulations adds container weight, which reduces blowing over of containers in growing beds.

Nurseries in Zimbabwe, South Africa, Australia and the west coast of the USA have used composted organic materials to produce tobacco seedlings in float trays for many years. One of the major limitations of the float tray system is the selection and availability of suitable substrate media for normal growth and development of tobacco seedlings (Judd, 1986). Although the pine bark proved the most appropriate substrate medium for tobacco seedling growth in the float tray system, its availability is limited and it is not the most cost-effective substrate material (Whicomb, 1988). The search for new substrates for soil-less tobacco seedling nurseries has become obligatory not only in Zimbabwe, but in most of the tobacco producing countries. Accordingly, we report in this study on an experiment led for 32 weeks with two composted organic materials mixed in different combinations with sand and pine bark to produce six types of media in which tobacco seedlings were grown. The objective of this study was to determine the most suitable substrate, other than the traditional pine bark-based substrates, for production of tobacco seedlings in float tray system, which provided higher germination percentages and improved seedling growth. We reasoned that different combinations of substrate and matrix materials presented variations in the physical and biochemical properties of seedling growth media in float trays, which were responsible for the differences in the biometric characteristics of tobacco seedlings.

Materials and Methods

The Field Study Site

The study was conducted at Kutsaga Research Station (17°52′ S; 31°02′ E, elev. >1500 m above sea level) near Harare International Airport in Zimbabwe. The soils at the research station are deeply weathered sandy loams derived from granite and classified as Udic Kandiustalf under the USDA system of soil classification (Nyamapfene, 1991). The area lies in Natural Region II receiving rainfall ranging from 800 to 1000 mm per annum (average 900 mm per annum) with a coefficient of variation of 19%. The mean annual temperature is 21°C with insignificant frost occurrence in the months of June and July (Vincent and Thomas, 1960). The rainfall occurs during a single rainy season extending from November to April.

Substrate Preparation for the Trial

Two crop residues, maize cobs and groundnut shells, were used as composting materials. After the harvesting of maize and groundnut crops, the two crop residues are readily available in Zimbabwe and many other African countries. The plant residues were ground separately to produce finer particles and shreds suitable for effective microbial decomposition. The materials were then placed in wooden boxes constructed with inside dimensions of 1.5×0.9×0.8 m to contain about $1m^3$ volume of substrate. Substrate samples were air-dried, ground to pass a 2 mm sieve, analyzed for organic C (Nelson and Sommers, 1982) and total N using the Kjeidahl procedure (Bremner and Mulvaney, 1982). These parameters were used to determine C: N ratios of each material. The aerobically composted substrates were also analyzed to determine total Ca, Mg and K using laboratory methods before and after composting. The pH_{H_2O} levels in filtrates from samples of each substrate were determined using a pH meter. The moisture content was maintained at 60% throughout the composting trial, which lasted for 20 weeks. In addition to that, ammonium nitrate was added to the compost in order to achieve a suitable nutrient balance for net mineralization of organic materials (Salonius, 1972). Temperature measurements at the centers of the deep compost stacks commenced on day 1 and at 3-day intervals via embedded probes (Yellow Springs, Inc., Series 400; Yellow Springs OH) and a monitor (Yellow Springs, Inc., Model 42SC; Yellow Springs OH). The composting was carried out under similar open-air aerobic conditions for each organic material.

Sampling for Microbial Analysis

Microbial analyses were performed after 12 weeks of composting on samples of decomposing materials collected from the center of each wooden box using sterilized thongs. The colony forming units of aerobic cellulolytic bacteria were enumerated on agarised Hudson's medium without antibacterial antibiotic treatments following the serial dilution techniques as outlined by Subba Rao (Hudson, 1972; Subba Rao, 1977).

Float Bed Design

The rectangular 30 cm deep float bed was constructed from common farm brick and mortar in a 9-inch wall. It was designed to ensure an inside width and length of about 1.1 and 4.1 m, respectively. These dimensions made it possible to place three rows containing 6 float trays each to give a total of 18 trays required in the replications. Float trays measuring 67 cm length, 34.5 cm width and 6 cm depth were used in the experiment. The entire construction was lined with 250 μ black plastic sheeting, which was at least 1.5 m wider and longer than the inside dimensions of the bed to allow for the plastic to be laid over the top of the wall to hold the plastic in place. The beds were then filled with water to a depth of 12-15 cm throughout. This effectively flattened the plastic against the sides of the pond and any wrinkles were pulled straight during this final exercise.

Treatments

The field trial was conducted during the 2004/2005 summer season. Composting of the maize cobs and groundnuts shells commenced in the early spring on 7 August 2004 and was concluded in December. Samples of the composted organic materials were ground to pass a 6 mm sieve in order to obtain particle sizes compatible with the dimensions of the float tray cells. Various combinations between compost samples themselves, composted (commercial) pine bark and washed river sand produced six treatments as follows: T_1- 50% pine bark and 50% sand (control, farmer's present practice), T_2- 100% maize cobs, T_3- 100% groundnut shells, T_4- 50% maize cobs and 50% sand, T_5- 50% groundnut shell and 50% sand, T_6- 50% groundnut shells and 50% maize.

The experiment was designed as Randomized Complete Block with three replicates, which were subjected to various combinations of organic substrates and substrate matrices as alternatives to pine bark in order to determine their effect on growth and development of tobacco seedlings produced under floating tray system.

Trial Management

The substrates were mixed according to treatment specifications to produce tobacco seedling growing media. Each float tray was filled with approximately 5 L volume of media. The amount of water needed to moisten the substrates depended largely on the type of media. About one-fifths of the volume of media was the amount of water added to the mix. A mix containing the correct amount of moisture holds its shape when squeezed into a ball for 2-3 sec before beginning to fall apart. Each tray was hand filled with the prepared media compositions by applying the standard methods. The trays were lifted to a height of about 20 cm above a flat surface and dropped gently. This slightly compacted the media in the trays. This was repeated 2-3 times with the trays being refilled after each drop. Under packing result in media falling out through the holes at the bottom of the cells whilst over packing introduces problems with dibbling and spiral roots. The trays were then dibbled using a dibble board and sown with pelleted KRK26 tobacco seed cultivar. Each cell was then pressed at the center to create depressions (dibbles) 1 cm deep.

The recommended basal fertilizer hydrofert with NPK 20:10:20 was used at rates of 150 mg L^{-1} of water split into three application rates of 25, 50, 75 mg L^{-1} at 7, 21 and 35 Days After Sowing (DAS), respectively. Top dressing by ammonium nitrate to pond water was done at 42 days after sawing using a rate of 100 mg N L^{-1} of water. Tobacco seedlings were clipped by cutting off leaf tips to ensure uniformity and allow seedlings that lagged in growth and development to catch up with others. Clipping commenced at 5-7 cm height up to transplantable age.

Measurements of Biometric Characteristics of Tobacco Seedlings

Measurements on dry cells and fall-outs were done 7 DAS. Germination and spiral roots counts commenced 14 DAS up to 42 DAS at weekly intervals. Spiral rooting is a condition when aerial roots develop as a result of a failure to go down due to compaction of the media or lack of sufficient oxygen in the media mix. At 12 weeks after sawing, measurements were done to establish stem length and diameter, dry mass of shoots and roots and the number of transplantable tobacco seedlings for each treatment. These measurements were taken from 50 center cells of each floating tray. Veneer callipers were used to determine seedling stem diameters taken just above the root crown. After separation of shoots from roots, samples were oven-dried at 80°C for 3 days and weighed. Analysis of variance (ANOVA) was used to test the significance of treatments effects on the biometric characteristics of tobacco seedlings grown in the float bed (MSTAT, 1988).

Results and Discussion

Table (1-7) show biochemical and physical characteristics of different organic substrates and their effects on the growth and development of tobacco seedlings grown in float beds. In the two crop residues there was a strong presence of *Bacillus* and *Streptococcus* and a conspicuous absence of *Salmonella*, *E. coli* and *Staphylococcus* bacteria (Table 1). This mosaic of decomposer microbes was largely determined by the composition of substrate (Table 2). Hyvonen and Agren (2001) and Myers *et al.* (2001) made similar observations on almost similar studies when they concluded that the wide variety in the chemical constituents of the plant litter significantly determines the decomposer microbial community composition.

The maize cob substrate supported the highest microbial community growth, with a robust *Bacillus* decomposer population of 96, 000, 000 colony forming units in the sample. The bacterial decomposer biomass bulge in the maize cob substrate was about 300 times more than that in the groundnut substrate at the end of composting (Table 1). This trend in the microbial community presence was coupled with corresponding peak substrate mass temperature of 60.5°C in maize cobs compared with peak temperature of 23.8°C in the groundnut shells attained at the beginning of the composting process (Fig. 1). The most rapid organic mass temperature build-ups were observed in the maize cobs where more than 60°C was clocked within the first 14 days of composting before leveling out to about 30°C. The steep decline in temperature in the maize cob mass from 60°C between 2 and 4 weeks to 30°C at 6 weeks (Fig. 2) until pulling stage was caused by the denaturation of microbial enzymes at around 45°C. At 60°C most enzymes cease to function. This, perhaps, explains why this was the maximum temperature recorded in the maize cob substrate. After the denaturation of the decomposer enzymes between 45 and 60°C the energy-releasing enzymatic breakdown of crop residues was significantly (f = 0.001) retarded. Temperatures in the groundnut mass were relatively uniform (19.4-23.1°C) due to lower decomposer microbial counts.

The significant difference in the decomposer biomass population and heat energy generation did not match the relatively narrow margin in the content of total C in maize cobs and groundnut substrates of 98.05 and 94.68 % of wet substrate weight, respectively. It would have been logical for the two substrates with such a narrow difference in total C content to score similar counts of heterotrophic micro-biotica. Such, however, was not the case in this study. The maize cob substrate had higher microbial counts than the groundnut shells. In a study on the mineralization processes in nitrate limited and non-limited residue-amended soil, McKenney *et al.* (1995) observed net immobilization of N in red clover legume residue with as low C: N ratio as 1/15. The high content of polyphenols commonly found in legume residues affect the release of N necessary for microbial protein synthesis from decomposing organic material by forming stable complexes with proteins (the tanning effect) thereby rendering both the N and C inaccessible to decomposer micro-

Table 1: Bacterial content of composting material at week 12

	Type of composting organic material (cfu g^{-1})	
Type of bacteria	Maize cobs	Groundnut shells
Bacillus	96,000,000	330,000
Streptococcus	40	10

NB: *Salmonella*, *E. coli* and *Staphylococcus* were absent in the samples, CFU- Colony forming units

Table 2: Chemical analysis before and after composting

	Maize cobs		Groundnut shells	
Measured components	Before composting	After composting	Before composting	After composting
pH	4.53	6.13	5.22	5.49
Content of wet sample (%)				
Ca	0.06	0.16	0.16	0.35
Mg	0.07	0.11	0.12	0.11
Na	0.01	0.03	0.01	0.02
K	0.95	0.71	1.15	0.19
Total N	0.60	3.09	0.89	2.25
Total C	98.05	95.19	94.68	90.70
Ratio				
C: N Ratio	164:1	31:1	106:1	40:1

Table 3: Germination and seedling survival percentages

	Days after sowing				
Treatments	14	21	28	35	42
T_1	34.0ab	77.2a	82.8b	83.2bc	80.0cd
T_2	14.5a	58.2a	52.5a	46.2a	27.3a
T_3	12.5a	59.8a	71.5b	75.5b	68.7b
T_4	42.0ab	86.5ab	84.2b	73.0b	54.2b
T_5	34.3ab	73.7a	72.2b	74.8b	69.5bc
T_6	16.7a	68.2a	72.3b	66.0b	36.6a

*Values followed by the same letter(s) are not significantly different

Table 4: Spiral roots percentage

	Days after sowing				
Treatments	14	21	28	35	42
T_1	1.0^{a}	7.5bc	4.7b	3.5ab	2.2ab
T_2	0.7a	0.5a	0.8a	2.0a	0.7a
T_3	0.0a	0.0a	1.2a	1.0a	0.0a
T_4	0.8a	5.5b	5.0b	4.8bc	2.3ab
T_5	1.2a	4.0b	1.8a	0.8a	0.8a
T_6	1.7a	0.7a	1.2a	1.7a	1.8ab

*Values followed by the same letter(s) are not significantly different

Table 5: Dry matter (g/seedling) of shoots and roots at pulling

Treatments	Shoots	Roots	Shoot/Root ratio
T_1	0.56b	0.11b	5.22a
T_2	0.9c	0.24c	3.65a
T_3	0.49b	0.09b	5.49b
T_4	0.89c	0.25c	3.63a
T_5	0.46b	0.11b	4.18a
T_6	0.28a	0.05a	5.66b

*Values followed by the same letter(s) are not significantly different

Table 6: Seedling size at pulling (stem length and diameter, mm)

Treatments	Stem diameter (mm)	Stem length (mm)
T_1	5.3b	159.5c
T_2	6.7b	37.3a
T_3	5.1b	137.9c
T_4	6.6c	35.5b
T_5	5.3b	155.6c
T_6	3.0a	12.6a

* Values followed by the same letter(s) are not significantly different

Table 7: Percentage transplantable seedlings

Treatments	Transplantable seedlings (%)
T_1	66.8c
T_2	4.9a
T_3	65.2c
T_4	4.5a
T_5	63.0c
T_6	15.8ab

* Values followed by the same letter(s) are not significantly different

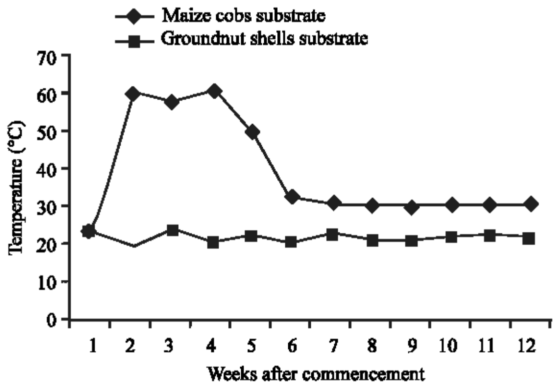

Fig. 1: Temperature changes during decomposition over three months

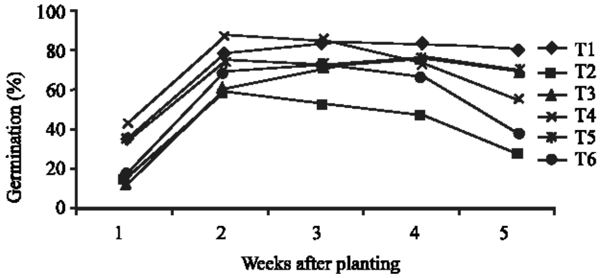

Fig. 2: Changes in germination percentages over six weeks

flora. Berg and Staaf (1980) reported similar trends in a study on the decomposition rate and chemical changes of Scots pine needle litter. This, perhaps, explains the low heterotrophic microbial count and the relatively lower substrate temperature in the legume substrate observed in this study. Elevated micro-floral counts in the maize cobs substrate encouraged increased energy-releasing metabolic processes, which accounted for the high temperatures recorded in this substrate.

Lower initial Ca, Mg, K and total N levels in the maize cobs substrate (0.06, 0.07, 0.95 and 0.60%) were associated with higher microbial decomposer fluxes while their higher contents (0.16, 0.12, 1.15 and 0.89%) in the groundnut material supported subdued microbial biomass for the reasons given above. In contrast, the earlier pattern was effectively reversed by the relationship between the content of C and that of N in the compost substrate (C: N ratio). A wider C: N ratio in the maize cobs substrate (164: 1) accommodated higher populations of decomposer bacterial biomass than that in the groundnut organic material (106: 1). The contents of C per unit mass of N in the pre-compost samples were significantly diminished by as much as 500 and 250% in the post-compost samples of maize cobs and groundnut shells, respectively. This trend in the C: N ratio was particularly interesting considering that the there were very narrow margins in the reductions of total C contents of 2.86 and 3.98 percentage points in the maize cobs and groundnut shells, respectively. Total N fluxes in the composting materials were a complete opposite of the total C fluctuations in the same materials. There were comparatively significant (f = 0.003) build-ups of total N in the composted organic materials (Table 2), which accounted for about 97.04% in the C: N ratio variance. In this study, small amounts of ammonium nitrate fertilizer were added to each organic substrate, which supplied the N that caused a bulge in the total N content leading to narrowing of the C: N ratio observed in the composts. Results on the dynamics of K, Ca, Mg and Na in the pre-compost and post-compost samples of the organic materials were less convincing as they did not show any definite trend (f>0.005).

The highest soluble acidity reductions were recorded in the maize cobs where a decrease of 1.6 pH units compared with 0.27 pH units in the groundnut shells were observed (Table 2). A large body of literature indicate that the net result of the oxidative microbial decomposition of organic substrates is the generation of strong organic and inorganic acids, which increase the H potency of such environments. In this study, the microbial oxidative decomposition of the two substrates, despite the generation of strong acids in this process, led to the reduction of soluble acidity by about 0.27-1.6 pH units. This, however, was not particularly surprising because in the decomposition of the organic substrates, complex semi-humus organic materials are generated with very high cation adsorption and incorporation capacities. The elevated ability of these complex partially decomposed semi-humus organic materials to initially adsorb H^+ from acids before incorporating it as residual acidity (organic colloidal buffer systems) explains the reduction of substrate soluble acidity observed in this study.

Table (3-7) show the biometric characteristics of tobacco seedlings grown in different media generated by various combinations of substrates in float trays. Results show that there were significant treatment differences in the germination percentages (f = 0.003). The lowest initial seed germination was observed in T_2, T_3 and T_6 float trays, which, notably, did not include the sand matrix in the seedling growth media cocktail. Amongst the three seedling growth media, T_2 treatment had the highest tobacco seedling mortality where a modest 58.2% germination rate was attained before rapidly dwindling to 27.3% seedling survival rate at pulling stage. The seedling growth media without the sand combination in float bed system had the lowest seedling survival percentage of a paltry 27.3%. Control treatment in which the growth media had 50% pine bark and 50% sand supported the highest tobacco seedling survival rates of 80% at transplantable stage (f = 0.002). Of particular interest in the findings of this study was the fact that all growth media with sand in their combinations supported relatively high germination and seedling survival rates of 68.7-80.0% (T_1, T_4 and T_5).

This pattern of treatment effect on tobacco seedling germination and growth was not particularly surprising as it concurred with research findings elsewhere. Blom (1993) reported that blending different seedling growth media components generates physical and chemical media characteristics that are intermediate between properties of the components. In this study the quartz component provided improved water retention capacity while the organic part offered good aeration in the media. Fonteno ***et al***. (2001) observed two critical physical attributes of container media namely, aeration and water holding porosity, which constitute total porosity. For favourable physical characteristics to be present in the container media, total porosity should comprise over 50% of the media volume. The combination of sand and organic substrate components in the growth media created superior physical properties of the growth media conducive for successful germination, growth and survival of tobacco seedlings. In T_1, T_4 and T_5 media the possibility of encountering dry cells in the float trays was far and wide apart. Dry cells occurrences in the float trays amplify seedling mortality rates. In addition to the above, sand blending in media formulations add container weight, which reduces blowing over of containers in growing beds.

However, T_1 and T_4 quartz based seedling growth media produced relatively higher spiral rooting rates of 1.0-2.2 and 0.8-2.3%, respectively (Table 4). Seedling growth media without sand combinations in T_3 and T_2 float trays generated the least spiral rooting rates 0 and 0.7% at seedling pulling stage, respectively. It is important to note that T_3 (100% groundnut shells) and T_2 (100% maize cobs) growth media which produced the lowest spiral root percentages had single substrate combinations. Spiral rooting in the media combinations resulted from failure of the radicle to penetrate the substrate and this was probably due to compaction and anoxic conditions of growth media commonly associated with sand based media in T_1 and T_4 (Fonteno *et al*., 2001). Generally, spiral rooting significantly dwindled towards pulling stage ($F<0.005$) probably because spiral rooting is a compensatory mechanism that the seed adopts when the radicle fails to penetrate the media. With time, however, the spiraled roots successfully penetrated the relatively compacted media following the phenomenon of negative geotropism, which effectively nullified spiral root occurrence. T_3 (100% groundnut shells) and T_2 (100% maize cobs) growth media which did not contain sand had the lowest spiral root counts because of the absence of media compaction and dominance of aerobic rooting conditions.

Results shown in Table 5 distinctly indicate that there were significant treatment effects on the tobacco seedling biomass distribution in shoot and root systems ($F<0.005$). One particularly interesting finding of this study was the fact that media combinations that had the lowest tobacco seedling survival counts had the heaviest shoots and roots per plant station. T_2 and T_4 growth media, which recorded relatively lower seedling survival counts of 27.3 and 54.2% had the heaviest shoot and root weights of 0.9 and 0.24 g; 0.89 and 0.25 g per seedling, respectively. This trend in treatment effect on biomass distribution was generally perpetuated in the stem diameter patterns and effectively reversed ($F<0.005$) in the stem lengths of tobacco seedlings (Table 6). Growth media combinations in T_1 and T_3 coupled with T_5 float trays, which notably had the highest seedling survival rates of 80.0, 68.7 and 69.5% propagated the tallest stem lengths of 159.5, 137.9 and 155.6, respectively at pulling stage. The same treatments recorded the highest transplantable seedling percentages (Table 7). The heaviest shoot and root weights recorded in T_2 and T_4 were attributed to the nutrient compensatory effect on fewer seedlings that survived. This was because when fertilizer was added to the pond calculations were made for 100% germination and survival. High seedling mortalities recorded in T_2 and T_4 media combinations resulted in the surviving ones utilizing the nutrients available in abundance with reduced competition. The highest seedling survival counts recorded in T_1, T_3 and T_5 float trays caused greater seedling populations per tray in which stiff competition for available nutrients and water occurs. This had the effect of propagating relatively thinner and taller stems observed in this study.

There was no clearly detectable trend in the composting effect on the chemistry of maize cobs and pea nut hulls, which would determine decomposer microbial community composition. It could be argued that narrow differences in the chemistry of two substrates should have had correspondingly more homogeneous micro-floral community composition. In this study we could definitively conclude that the two substrates had micro-floristically different decomposer community biomass, but at the same time our results did not have adequate evidence to show why this was so. However, we relied on research results elsewhere, which have shown that the strongest determinants of decomposer microbial biomass and its composition are not only the content of total C and N, but the relative amounts of poly-phenols, which upon complexing with proteins, render both the N and C comparatively inaccessible to decomposer microbes. The ground nut shells, contain relatively higher amounts of poly-phenols and for this reason we concluded that this was why they had lower microbial counts than the maize cobs together with the associated lower substrate temperatures attained in the mass.

In our search for alternative media combinations to 50% pine bark and 50% sand mix, which was used as the control, study results suggest that the five alternative media combinations did not expose better seedling growth media qualities than the control in almost all the essential biometric characteristics of tobacco seedlings, which have a fundamental influence on the tobacco leaf yield parameters in the field. We concluded that this was largely due to superior physical properties commonly associated with such media combinations. The pine bark/sand media had peak germination rates of 83.2% and a seedling survival count of 80.0% compared with germination rates of 46.2-75.5% and survival counts of 27.3-69.5% in the other five media. In addition to that, the pine bark/sand media supported the highest seedling stem length of 159.5 mm at pulling. Nevertheless, T_3 and T_5 media combinations did not show entirely dismal results in the growth of tobacco seedlings and may require further investigations especially considering that this study did not have an economic comparison of the media combinations.

Acknowledgments

This manuscript is based on portion of a series of studies carried out at Kutsaga Research Station under the supervision of Dr. Jean Nzuma and B. Kachigunda. Our sincere gratitude goes to the institution and the above professionals in the academic guidance and management of the trials.

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